

This leads to very heavy work which could have been avoided by taking

$$U_x = A + B(x-a) + C(x-a)(x-b) + \dots$$

where $a, b, \dots$ are the values of x for which the function is given. This is actually given in a later chapter, but its use in this connection is not mentioned. The section on Two-Variable Interpolation seems out of place, in view of the introduction of a chapter dealing entirely with this branch of the subject. The short chapter on Central Differences, which is practically a reproduction of the obsolete, cumbersome, and imperfect demonstration given in the Institute of Actuaries' Text-book, part ii., might well have been dropped, as the work is redone by a better method in the chapter on Stirling's Formula. As is shown in the latter chapter, the formulæ follow at once from assumptions of the form

$$U_x = A + Bx + Cx(x-1) + D(x+1)x(x-1) + \dots$$

The authors, however, make their demonstrations unduly long by obtaining $U_0, \Delta U_0, \Delta^2 U_{-1}, \dots$ by detailed expression of $U_0, U_1, U_{-1}, \dots$ in terms of $A, B, \dots$. If U_x had been written in the form

$$A + Bx + \frac{Cx^{(2)}}{2!} + \frac{D(x+1)^{(3)}}{3!} + \dots$$

the difference of U_x for all values of x could have been written down without the tedious arithmetic which is employed. Two pages are devoted to the C.D. expansions of U_x in which the leading terms are $U_{\frac{1}{2}}$ and $U_{-\frac{1}{2}}$ respectively. All this is quite unnecessary, as the formulæ can be deduced from those already obtained by writing

$$U_x = U_{\frac{1}{2} + (x - \frac{1}{2})} \text{ or } U_{-\frac{1}{2} + (x + \frac{1}{2})}.$$

It is to be regretted that the opportunity was not taken to revise the chapter on Summation. The function is frequently written before the operator, and we have such surprising statements as

$$U_{a+x} = U_a(1+\Delta)^x,$$

$$U_a + U_{a+1} + \dots + U_{a+n-1} = U_a \left\{ n + \frac{n(n-1)}{2!} \Delta + \dots \right\}$$

and the operators are spoken of as the *coefficients* of U_a . The introduction of the alternative so-called demonstration for Lubbock's formula is unfortunate, as the symbolical method employed is quite unsound, and may be mistaken by students for a proof. The chapter on Interpolation of Inverse Functions, consisting mainly of two examples, is unnecessary, and the examples might have been incorporated with those on Lefrange's formula.

Three-quarters of the book (parts ii. to iv.) are taken up with solutions of questions set in the first examination of the Institute of Actuaries between the years 1887 and 1902. The questions include Permutations and Combinations, Binomial Theorem, Probabilities, and Elementary Finite

Differences. The solutions are instructive, but those on Finite Differences follow too closely the methods of algebra text-books instead of the neater methods of Finite Differences. The incorrect solution to problem 212 given in the first edition is repeated, and the solution to problem 202, giving the expression of $U_0 + U_1x + U_2x^2 + \dots$ in terms of differences of U_0 , should have been incorporated in the chapter on Summation. It would have been more useful to the students for whom the book is intended if solutions of questions from recent examination papers of the Institute of Actuaries had been given, as the syllabus now includes the elements of Differential and Integral Calculus.

PRACTICAL AND APPLIED CHEMISTRY.

- (1) *Practical Physical Chemistry*. By Dr. A. Findlay. Third edition. Pp. xvi + 327. (London: Longmans, Green and Co., 1914.) Price 4s. 6d. net.
- (2) *Practical Physical Chemistry*. By J. B. Firth. Pp. xii + 178. (London: Methuen and Co., Ltd., 1915.) Price 2s. 6d.
- (3) *Volumetric Analysis*. By A. J. Berry. Pp. 137. (Cambridge: At the University Press, 1915.) Price 6s. 6d. net.
- (4) *A First Course in Practical Chemistry for Rural Secondary Schools*. By W. Aldridge. Pp. xii + 122. (London: G. Bell and Sons, Ltd., 1915.) Price 1s. 6d.
- (5) *Dyestuffs and Coal-Tar Products: their Chemistry, Manufacture, and Application*. By T. Beacall, Dr. F. Challenger, Dr. G. Martin, and Dr. H. J. S. Sand. Pp. vii + 156. (London: Crosby, Lockwood and Son, 1915.) Price 7s. 6d. net.

(1) and (2) **T**HE third edition of Prof. Findlay's "Practical Physical Chemistry" contains a description of several new experimental methods, especially in connection with the determination of vapour-densities, surface-tension by the drop method, molecular-weights, solubility and hydrolysis of salts by conductivity-measurements, and the measurement of decomposition and of ionic-discharge potentials. The new edition retains all the merits which have long been recognised in its predecessors.

Mr. Firth's book is of a similar type to Prof. Findlay's, and seems to indicate that a standard course of physical chemistry has now been developed, and is being followed with very little modification in a number of different centres. The coincidence in this case extends not merely to identical illustrations of standard apparatus, but even to the inclusion in each volume of a picture

of a tabloid-press. The general character of the course is now too well known to call for detailed description.

In the opinion of the writer, the time is ripe for a revision of the optical experiments described in books of this type. The Continental form of the Pulfrich refractometer suffers from a seriously-defective form of water-jacketing, and might with advantage be replaced (in the text-book as well as in the laboratory) by the newer English instrument, which has been improved greatly in this respect. Similar statements may be made in reference to polarimetric apparatus, in which the English makers now enjoy a marked superiority, which might well find acknowledgment in books such as those now under review. The time is also ripe for recognising the great technical importance of the newer sources of monochromatic light, and the advantages they possess over those formerly in use. The introduction of lithium into the sodium flame and of a globule of mercury into a warmed hydrogen vacuum-tube provide, for use with a refractometer, a series of four lines which is much superior to the traditional series CDFG, which has come down to us from the period when sunlight was still the chief illuminant for optical experiments; the fact that the instrument will need to be calibrated for these four wave-lengths (e.g., with a crystal of quartz) is a real advantage from the point of view of the training of the student. For polarimetric work the enclosed mercury arc, which has now almost displaced the sodium flame, both in technical and in scientific laboratories, is ripe for description in the text-books; and it ought to be followed very soon by a description of Dr. Sand's enclosed cadmium arc, the brilliant invention of an English worker, which promises to revolutionise all those branches of optics which depend on the utilisation of powerful sources of monochromatic light. It is curious that both authors should be content with jacketed polarimeter tubes in which only about three-quarters of the liquid is under the direct control of the circulating water.

(3) Mr. Berry's "Volumetric Analysis" represents a distinct advance upon most of the smaller books on the subject, though its advantages are largely neutralised by the very high price which is charged for a volume of less than 140 pages. The method of treatment is more scholarly than is usual in a small text-book, and the inclusion of a chapter on the "Theory of Indicators," based on Mr. Tizard's well-known report, affords welcome recognition of the scientific aspects of the subject. If issued at half the present price the book could be commended heartily for general use in the many laboratories in which volumetric analysis is now taught.

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(4) Mr. Aldridge's book is little more than a skeleton, on which a useful course of elementary chemistry may be built up; but it gives the impression that the author is alive to the various educational features that may be embodied in such a course, and the suggestions which he makes should be of real value to other teachers who have not had so long an experience in work of this kind. Specially welcome is the stress which he lays on the full description written by the pupil of his experiments and observations, a description to be written in pencil at the laboratory bench, but written neatly, arranged logically, and expressed in the best English which the boy can command. Such an exercise is certainly better than the barren attempt to induce a boy to express in a formal essay pious opinions on a subject of which he has no special knowledge, and in which his interest is often non-existent.

(5) Dr. Martin's book on "Dyestuffs and Coal-tar Products," issued as the first of a series of manuals of chemical technology, is reprinted with additions from vol. i. of his well-known book on "Industrial and Manufacturing Chemistry," and does not, therefore, call for a detailed review. The sections reproduced deal with the coal-tar industry, synthetic colouring matters, natural dyestuffs, dyeing and colour-printing, inks, saccharine, and other sweetening chemicals, modern synthetic drugs, and photographic chemicals. The reproduction of these articles is very opportune at the present time, and will be generally welcomed.

T. M. L.

OUR BOOKSHELF.

The Principles of Agriculture through the School and the Home Garden. By C. A. Stebbins. Pp. xxvi+380. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1913.) Price 4s. 6d. net.

"DAISIES growing a girl" is the title of the frontispiece of this volume and aptly illustrates its aim. Through practical work in garden and classroom juvenile cultivators are led towards a broad outlook as members of the community. Problems of the garden lead, on the one hand, to problems of the farm, market, and finance, and on the other hand, to those of the home, city, and public health. By their own experience the children learn, not only how seeds germinate and where mosquitoes breed, but also how, on a plot of garden ground, each can take his share of responsibility as a citizen. There are score cards for everything from potatoes to personal hygiene. Even the latter the child scores for himself, and his record counts one-half for his own promotion from class to class in school! Such is "school-gardening" as actually carried out in the Western States to-day.

We wish that every school teacher in this country could read this volume. Every page is